

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Appellants: Pawlak et al.

Group Art Unit: 2812

Serial No.: 10/596,612

Examiner: Sene, Pape A.

Filed: June 19, 2006

Confirmation No.: 8409

For: SEMICONDUCTOR SUBSTRATE WITH SOLID PHASE EPITAXIAL
REGROWTH WITH REDUCED JUNCTION LEAKAGE AND METHOD OF
PRODUCING SAME

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APPEAL BRIEF UNDER 37 C.F.R. § 41.37(a)

This is an appeal to the Board of Patent Appeals and Interferences from the decision of the Examiner dated May 26, 2011, which finally rejected claims 1-10 in the above-identified application. A Notice of Appeal was filed on October 15, 2011. This Appeal Brief is hereby submitted pursuant to 37 C.F.R. § 41.37(a).

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I. REAL PARTY IN INTEREST

The real party in interest in this appeal is NXP B.V., High Tech Campus 60, 5656 AG Eindhoven, The Netherlands.

II. RELATED APPEALS AND INTERFERENCES

To the best of Appellants' knowledge, there are no appeals or interferences related to the present appeal that will directly affect, be directly affected by, or have a bearing on the Board's decision in the instant appeal.

III. STATUS OF CLAIMS

Claims 1-10 were originally filed on June 19, 2006. In a preliminary amendment filed on June 19, 2006, claims 4, 6, 7 and 10 were amended. In response to the Office Action of December 9, 2010, claim 8 was amended. Claims 1-10 stand finally rejected and form the subject matter of the present appeal.

Claims 1-10 stand rejected as follows:

Claims 1-5 stand rejected under 35 U.S.C. 103(a) as allegedly being unpatentable over Wang et al. (U.S. Pat. App. Pub. No. 2005/0054173, hereinafter "Wang") in view of Keys et al. (U.S. Pat. App. Pub. No. 2004/0235280, hereinafter "Keys").

Claim 6 stands rejected under 35 U.S.C. 103(a) as allegedly being unpatentable over Wang in view of Keys, and further in view of Sultan et al. (U.S. Pat. No. 6,063,682, hereinafter "Sultan").

Claim 7 stands rejected under 35 U.S.C. 103(a) as allegedly being unpatentable over Wang in view of Keys, and further in view of Xiang et al. (U.S. Pat. No. 6,555,439, hereinafter "Xiang"). However, Appellants note that claim 7 was actually rejected under 35 U.S.C. 103(a) as allegedly being unpatentable over Wang in view of Keys, and further in view of Maszara et al. (U.S. Pat. No. 6,362,063, hereinafter "Maszara").

Claims 8-10 stand rejected under 35 U.S.C. 103(a) as allegedly being unpatentable over Wang in view of Xiang.

A copy of the claims is set forth in the Claims Appendix.

IV. STATUS OF AMENDMENTS

No amendments were filed subsequent to the final rejection.

V. SUMMARY OF CLAIMED SUBJECT MATTER

This section of this Appeal Brief is set forth to comply with the requirements of 37 C.F.R. § 41.37(c)(1)(v) and is not intended to limit the scope of the claims in any way. Examples of implementations of the limitations of independent claims 1 and 8 are described below.

The language of claim 1 relates to a method of producing a semiconductor device. (Page 2, lines 4-18; Figs. 1a-1f). The method includes a) providing a semiconductor substrate (1), b) making a first amorphous layer (17) in a top layer of said semiconductor substrate (1) by a suitable implant, said first amorphous layer having a first depth, c) implanting a first dopant into said semiconductor substrate (1) to provide said first amorphous layer (17) with a first doping profile, d) applying a first solid phase epitaxial regrowth action to partially regrow said first amorphous layer (17) and form a second amorphous layer having a second depth that is less than said first depth and activate said first dopant, e) implanting a second dopant into said semiconductor substrate (1) to provide said second amorphous layer with a second doping profile with a higher doping concentration than said first doping profile, and f) applying a second solid phase epitaxial regrowth action to regrow said second amorphous layer and activate said second dopant. (Page 2, lines 4-18; Figs. 1a-1f and 3).

The language of claim 8 relates to a semiconductor device made by a solid phase epitaxial regrowth technique. (The paragraph beginning at page 2, line 30 and page 5, lines 16-24; Figs. 1a-1f and 3). The semiconductor device comprises a semiconductor substrate (1) with a first area having a first conductivity profile and a second area having a second conductivity profile, the second area having a thickness of 6-12 nm and being located adjacent to a top surface of said semiconductor substrate, and said first area having a thickness of 2-6 nm and being located adjacent to said second area, said second conductivity profile having a lower conductivity than said first conductivity profile. (The paragraph beginning at page 2, line 30 and page 5, lines 16-24;

Figs. 1a-1f and 3). The second area is located closer to the top surface of said semiconductor substrate than the first area. (Page 5, lines 16-24; Fig. 3).

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

- A. Whether or not independent claim 1 is unpatentable over Wang in view of Keys under 35 U.S.C. 103(a).
- B. Whether or not independent claim 8 is unpatentable over Wang in view of Xiang under 35 U.S.C. 103(a).
- C. Whether or not dependent claims 2-7, 9 and 10 are unpatentable over Wang in view of Keys, Sultan, Maszara or Xiang under 35 U.S.C. 103(a).

VII. ARGUMENT

- A. Appellants respectfully assert that independent claim 1 is patentable over Wang in view of Keys under 35 U.S.C. 103(a).

Appellants respectfully assert that a *prima facie* case of obviousness rejection have not been established with respect to claim 1. Specifically, Appellants respectfully assert that the articulated reasoning provided by the Examiner with respect to combining the teachings of Wang and Keys is not based on a rational underpinning.

In order to establish a *prima facie* case of obviousness of a claim under 35 U.S.C. 103, the Office Action must present a clear articulation of the reason why the claimed invention would have been obvious. MPEP 2142 (citing *KSR International Co. v. Teleflex Inc.*, 550 U.S. 398 (2007)). The analysis must be made explicit. Id. Additionally, rejections based on obviousness cannot be sustained by mere conclusory statements; instead there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness. Id.

Claim 1 recites:

*“Method of producing a semiconductor device comprising:
a) providing a semiconductor substrate,
b) making a first amorphous layer in a top layer of said semiconductor substrate by*

a suitable implant, said first amorphous layer having a first depth,
c) implanting a first dopant into said semiconductor substrate to provide said first amorphous layer with a first doping profile,
d) applying a first solid phase epitaxial regrowth action to partially regrow said first amorphous layer and form a second amorphous layer having a second depth that is less than said first depth and activate said first dopant,
e) implanting a second dopant into said semiconductor substrate to provide said second amorphous layer with a second doping profile with a higher doping concentration than said first doping profile,
f) applying a second solid phase epitaxial regrowth action to regrow said second amorphous layer and activate said second dopant.”

The Examiner acknowledges in the Final Office Action of May 26, 2011 that Wang does not teach the limitations “*applying a first solid phase epitaxial regrowth action to partially regrow said first amorphous layer and form a second amorphous layer having a second depth that is less than said first depth and activate said first dopant,*” as recited in claim 1. (See page 3 of the Final Office Action). In addition, the Examiner suggests that Keys teaches the above-identified limitation of claim 1. (See page 3 of the Final Office Action). The Examiner then concludes that “[i]t would have been obvious to a person of ordinary skill in the art at the time of the invention was made, to partially regrow the first amorphous layer, as taught by Keys, for the purpose of forming shallow junctions” (emphasis added). (See page 3 of the Final Office Action). However, Appellants respectfully assert that a person of ordinary skill in the art at the time of the invention was made would not combine the teachings of Wang and Keys, as suggested by the Examiner.

Wang teaches that a pre-amorphization implantation (206) is carried out on a substrate (200) to form an amorphized region (208). (See Fig. 2B and paragraph [0026] of Wang). The Examiner suggests in the Final Office Action of May 26, 2011 that the amorphized region (208) of Wang is equivalent to the “*first amorphous layer*” as recited in claim 1. (See page 3 of the Final Office Action). In addition, as shown in step S112 in Fig. 1, Fig. 2D and step S312 in Fig. 3, Wang teaches that a doped source/drain region (218) is formed in a lower portion of the amorphized region (208) under a doped source/drain extension region (212) on each side of a spacer (214) and is not on the surface of the substrate (200). (See also paragraphs [0027], [0029], [0031], [0039], and [0041] of Wang). The Examiner suggests in the Final Office Action of May 26, 2011

that the doped source/drain region (218) of Wang is equivalent to the “*second amorphous layer*” as recited in claim 1. (See page 3 of the Final Office Action).

Keys teaches that recrystallization inhibitors (206) are implanted into a surface area of an amorphous region (202) that is on the surface area of a semiconductor substrate. (See Fig. 2A and paragraph [0025] of Keys). The Examiner suggests in the Final Office Action of May 26, 2011 that the amorphous region (202) of Keys is equivalent to the “*first amorphous layer*” as recited in claim 1. (See page 3 of the Final Office Action). In addition, Keys teaches that the recrystallization inhibitors (206) are capable of inhibiting or substantially retarding the solid phase epitaxial regrowth (or recrystallization) of a semiconductor substrate that has been amorphized. (See paragraph [0025] of Keys). Keys also teaches that dopants (207) can be implanted into the surface area of the amorphous region (202) that includes the recrystallization inhibitor region (206) to create shallow source/drain extensions. (See Fig. 2B and paragraph [0027] of Keys). Furthermore, Keys teaches that before or after the dopants (207) are implanted into the amorphous region (202), the amorphous region (202) is partially recrystallized. (See Figs. 2A and 2B and paragraphs [0029] of Keys). Keys also teaches that the part of the amorphous region (202) that does not have the recrystallization inhibitors (206) recrystallizes to form a recrystallized region (211) and the surface area of the amorphous region (202) that includes the recrystallization inhibitors (206) remains amorphous after the partial recrystallization. (See Fig. 2B and paragraphs [0028] and [0030] of Keys). Lastly, Keys teaches that defects (208) are spatially separated from the surface area of the amorphous region (202) that includes the recrystallization inhibitors (206). (See Fig. 2B and paragraph [0030] of Keys). That is, Keys teaches partially recrystallizing the amorphous region (202) such that the surface area of the amorphous region (202), which is on the surface area of the semiconductor substrate, remains amorphous after the partial recrystallization and is separated from defects to allow a shallow junction to form.

As described above, Wang teaches that the doped source/drain region (218) is formed in a lower portion of the amorphized region (208) under the doped source/drain extension region (212), which is at the surface area of the substrate (200). That is, Wang teaches that the doped source/drain region (218) is **not** formed on the surface area of the substrate (200). However, as described above, Keys teaches partially recrystallizing the

amorphous region (202) such that the surface area of the amorphous region (202), which is on the surface area of the semiconductor substrate, remains amorphous. Because Keys teaches partially recrystallizing the amorphous region (202) such that the surface area of the amorphous region (202), which is on the surface area of the semiconductor substrate, remains amorphous, combining the teachings of Wang and Keys would result in that the doped source/drain region (218) of Wang is formed on the surface area of the substrate (200). Because Wang teaches that the doped source/drain region (218) is **not** formed on the surface area of the substrate (200), a person of ordinary skill in the art at the time of the invention was made would **not** apply Keys' teachings of partially recrystallizing the amorphous region (202) to the teachings of Wang. Therefore, Appellants respectfully assert that a person of ordinary skill in the art at the time of the invention was made would not combine the teachings of Wang and Keys as suggested by the Examiner.

In addition, although the Examiner provides some statements in the Advisory Action of August 29, 2011, the statements in the Advisory Action of August 29, 2011 do not cure the deficiency of the Final Office Action of May 26, 2011. Thus, Appellants respectfully assert that the articulated reasoning provided by the Examiner with respect to combining the teachings of Wang and Keys is not based on a rational underpinning. As a result, Appellants respectfully assert that a *prima facie* case of obviousness rejection have not been established with respect to claim 1. As a result, Appellants respectfully submit that claim 1 is patentable over Wang in view of Keys.

B. Appellants respectfully assert that independent claim 8 is patentable over Wang in view of Xiang under 35 U.S.C. 103(a).

Appellants respectfully assert that Wang in view of Xiang does not teach all of the limitations of claim 8. In addition, Appellants respectfully assert that the articulated reasoning provided by the Examiner with respect to combining the teachings of Wang and Xiang is not based on a rational underpinning. Accordingly, Appellants respectfully assert that claim 8 is patentable over Wang in view of Xiang.

Appellants respectfully assert that Wang in view of Xiang does not teach all of the limitations of claim 8.

Claim 8 recites:

“Semiconductor device made by a solid phase epitaxial regrowth technique, comprising a semiconductor substrate with a first area having a first conductivity profile and a second area having a second conductivity profile, the second area having a thickness of 6-12 nm and being located adjacent to a top surface of said semiconductor substrate, and said first area having a thickness of 2-6 nm and being located adjacent to said second area, said second conductivity profile having a lower conductivity than said first conductivity profile, wherein the second area is located closer to the top surface of said semiconductor substrate than the first area” (emphasis added).

Appellants respectfully assert that Wang in view of Xiang does not teach all of the limitations of claim 8. The Examiner suggests in the Final Office Action of May 26, 2011 that Wang teaches all of the limitations of claim 8 except the limitation “*said first area having a thickness of 2-6 nm.*” (See page 6 of the Final Office Action). Xiang is cited for teaching the limitation “*said first area having a thickness of 2-6 nm*” as recited in claim 8. The Examiner then concludes that “[i]t would have been obvious to a person of ordinary skill in the art at the time of the invention was made, to make the first area have a thickness of 2-6 nm, as taught by Xiang, and therefore make the second area have a thickness of 6-12 nm, for the purpose of speeding recrystallization and amorphization” (emphasis added). (See page 6 of the Final Office Action).

As described above with respect to the rejection of claim 1, Wang teaches that the doped source/drain region (218) is formed in the substrate (200) on each side of the spacer (214). Wang also teaches that a doped source/drain extension region (212) is formed in the substrate (200) on each side of a spacer (205). (See step S108 in Fig. 1, Fig. 2C and step S308 in Fig. 3 and paragraphs [0027], [0031], [0037], and [0040] of Wang). In addition, Wang teaches that an amorphized region (208) is formed in the substrate (200).

The Examiner in the annotated Fig. 2D on page 7 of the Final Office Action indicates that the combination of the doped source/drain extension region (212) and the doped source/drain region (218) of Wang is equivalent to the “*second area having a second conductivity profile*” as recited in claim 8. In addition, the Examiner in the annotated Fig. 2D on page 7 of the Final Office Action indicates that the amorphized

region (208) of Wang below the doped source/drain region (218) is equivalent to the “*first area having a first conductivity profile*” as recited in claim 8.

As described above, the Examiner suggests in the Final Office Action of May 26, 2011 that Wang teaches all of the limitations of claim 8 except the limitation “*said first area having a thickness of 2-6 nm.*” However, Appellants respectfully assert Wang does not teach that the conductivity profile of the combination of the doped source/drain extension region (212) and the doped source/drain region (218) (“*second area having a second conductivity profile*”) is lower than the conductivity profile of the amorphized region (208) below the doped source/drain region (218) (“*first area having a first conductivity profile*”). Because Wang does not teach that the conductivity profile of the combination of the doped source/drain extension region (212) and the doped source/drain region (218) is lower than the conductivity profile of the amorphized region (208), Appellants respectfully assert that Wang does not teach “*said second conductivity profile having a lower conductivity than said first conductivity profile*” (emphasis added), as recited in claim 8.

Appellants respectfully assert that the articulated reasoning provided by the Examiner with respect to combining the teachings of Wang and Xiang is not based on a rational underpinning.

The only statement made by the Examiner in support of an obviousness rejection of claim 8 is that “[i]t would have been obvious to a person of ordinary skill in the art at the time of the invention was made, to make the first area have a thickness of 2-6 nm, as taught by Xiang, and therefore make the second area have a thickness of 6-12 nm, for the purpose of speeding recrystallization and amorphization” (emphasis added) on page 6 of the Final Office Action, which is a mere conclusory statement and fails to clearly articulate a rationale in support of the obviousness rejection, as required by the MPEP and KSR. In the Final Office Action of May 26, 2011, the Examiner failed to clearly articulate why the combination of the teachings of Wang and Xiang would speed recrystallization and amorphization. In addition, the Examiner also failed to clearly articulate how the teachings of Wang and Xiang would be combined to speed recrystallization and amorphization.

In view of the foregoing, Appellants respectfully submit that the Examiner has merely provided a conclusory statement in support of the obviousness rejection and failed to clearly articulate a rational to support his conclusion, as required by the MPEP and *KSR*. In addition, although the Examiner provides some statements in the Advisory Action of August 29, 2011, the statements in the Advisory Action of August 29, 2011 do not cure the deficiency of the Final Office Action of May 26, 2011. Thus, Appellants respectfully assert that the articulated reasoning provided by the Examiner with respect to combining the teachings of Wang and Xiang is not based on a rational underpinning. Accordingly, Appellants respectfully assert that claim 8 is patentable over Wang in view of Xiang.

C. Appellants respectfully assert that dependent claims 2-7, 9 and 10 are patentable over Wang in view of Keys, Sultan, Maszara or Xiang under 35 U.S.C. 103(a).

Given that claims 2-7, 9 and 10 depend from and incorporate all of the limitations of the corresponding independent claims 1 and 8, Appellants respectfully submits that claims 2-7, 9 and 10 are allowable at least based on allowable claims 1 and 8. Additionally, each of claims 2-7, 9 and 10 may be allowable for further reasons.

VIII. CONCLUSION

A *prima facie* case of obviousness has not been established with respect to independent claims 1 and 8. Thus, independent claim 1 is not obvious over Wang in view of Keys under 35 U.S.C. 103(a) and independent claim 8 is not obvious over Wang in view of Xiang under 35 U.S.C. 103(a). In addition, dependent claims 2-7, 9 and 10 are allowable at least based on allowable claims 1 and 8 since claims 2-7, 9 and 10 depend from and incorporate all of the limitations of the corresponding independent claims 1 and 8.

For the reasons stated above, claims 1-10 are patentable over the cited references. Appellants respectfully request that the Board reverse the rejections of claims 1-10.

At any time during the pendency of this application, please charge any fees required or credit any over payment to Deposit Account **50-4019** pursuant to 37 C.F.R.

1.25. Additionally, please charge any fees to Deposit Account **50-4019** under 37 C.F.R.
1.16, 1.17, 1.19, 1.20 and 1.21.

Respectfully submitted,

Date: December 14, 2011

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IX. CLAIMS APPENDIX

1. Method of producing a semiconductor device comprising:

- a) providing a semiconductor substrate,
- b) making a first amorphous layer in a top layer of said semiconductor substrate by a suitable implant, said first amorphous layer having a first depth,
- c) implanting a first dopant into said semiconductor substrate to provide said first amorphous layer with a first doping profile,
- d) applying a first solid phase epitaxial regrowth action to partially regrow said first amorphous layer and form a second amorphous layer having a second depth that is less than said first depth and activate said first dopant,
- e) implanting a second dopant into said semiconductor substrate to provide said second amorphous layer with a second doping profile with a higher doping concentration than said first doping profile,
- f) applying a second solid phase epitaxial regrowth action to regrow said second amorphous layer and activate said second dopant.

2. Method according to claim 1, wherein said semiconductor substrate is a Si substrate and action b) is performed with at least one of Ge, GeF₂, Si, Ar or Xe atoms.

3. Method according to claim 2, wherein said action b) is performed with Ge in a dose of 10¹⁵ atoms/cm² and an energy between 2 and 30 keV.

4. Method according to claim 1, wherein said action c) is performed with at least one of B, P, As and In at an energy between 3 and 10 keV, and a dose of 10¹⁴ atoms/cm².

5. Method according to claim 5, wherein action d) is performed at a temperature of 550-750 °C during a few seconds.

6. Method according to claim 1, wherein said action e) is performed with at least one of B, P, As and In at an energy between 0.5 and 3 keV, and a dose of 10¹⁵ atoms/cm².

7. Method according to claim 1, wherein prior to said action b), an initial dopant is implanted to provide a HALO implant area extending deeper than said first amorphous layer.

8. Semiconductor device made by a solid phase epitaxial regrowth technique, comprising a semiconductor substrate with a first area having a first conductivity profile and a second area having a second conductivity profile, the second area having a thickness of 6-12 nm and being located adjacent to a top surface of said semiconductor substrate, and said first area having a thickness of 2-6 nm and being located adjacent to said second area, said second conductivity profile having a lower conductivity than said first conductivity profile, wherein the second area is located closer to the top surface of said semiconductor substrate than the first area.

9. Metal oxide semiconductor device comprising a device as claimed in claim 8.

10. Apparatus provided with a semiconductor device as claimed in claim 8.

X. EVIDENCE APPENDIX

There is no evidence submitted with this Appeal Brief.

XI. RELATED PROCEEDINGS APPENDIX

To the best of Appellants' knowledge, there are no appeals or interferences related to the present appeal that will directly affect, be directly affected by, or have a bearing on the Board's decision in the instant appeal.